Polar Ozone Loss in the GMI Hindcast and GSFC CTM Simulations

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GMI Meeting, Atlanta, GA January, 2006

Chemistry climate model diagnostic: Delta Ozone vs V_{psc}

- Empirical relationship derived from data
- Issues
  - Calculating ozone loss not straightforward
  - Vpsc can be calculated in several ways - doesn't always agree with direct observations
  - Chlorine dependence?
- Results in alarmingly straight line

Delta Ozone vs Volume of PSCs

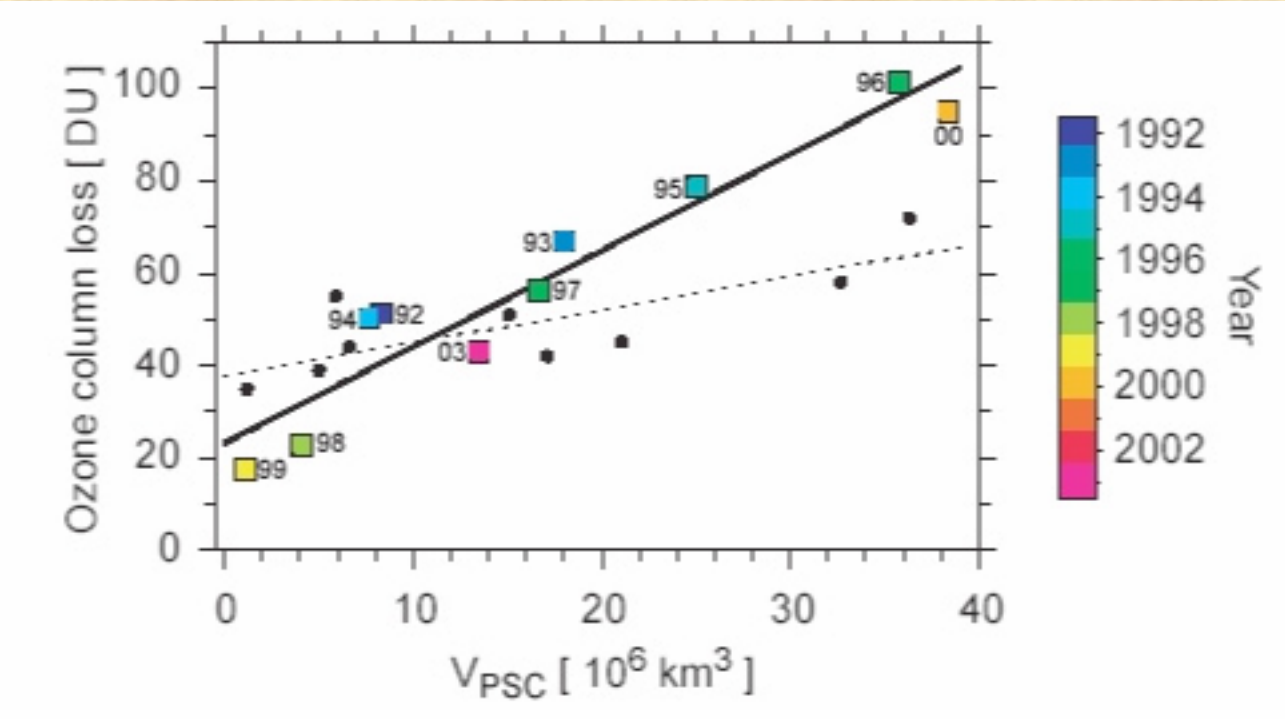
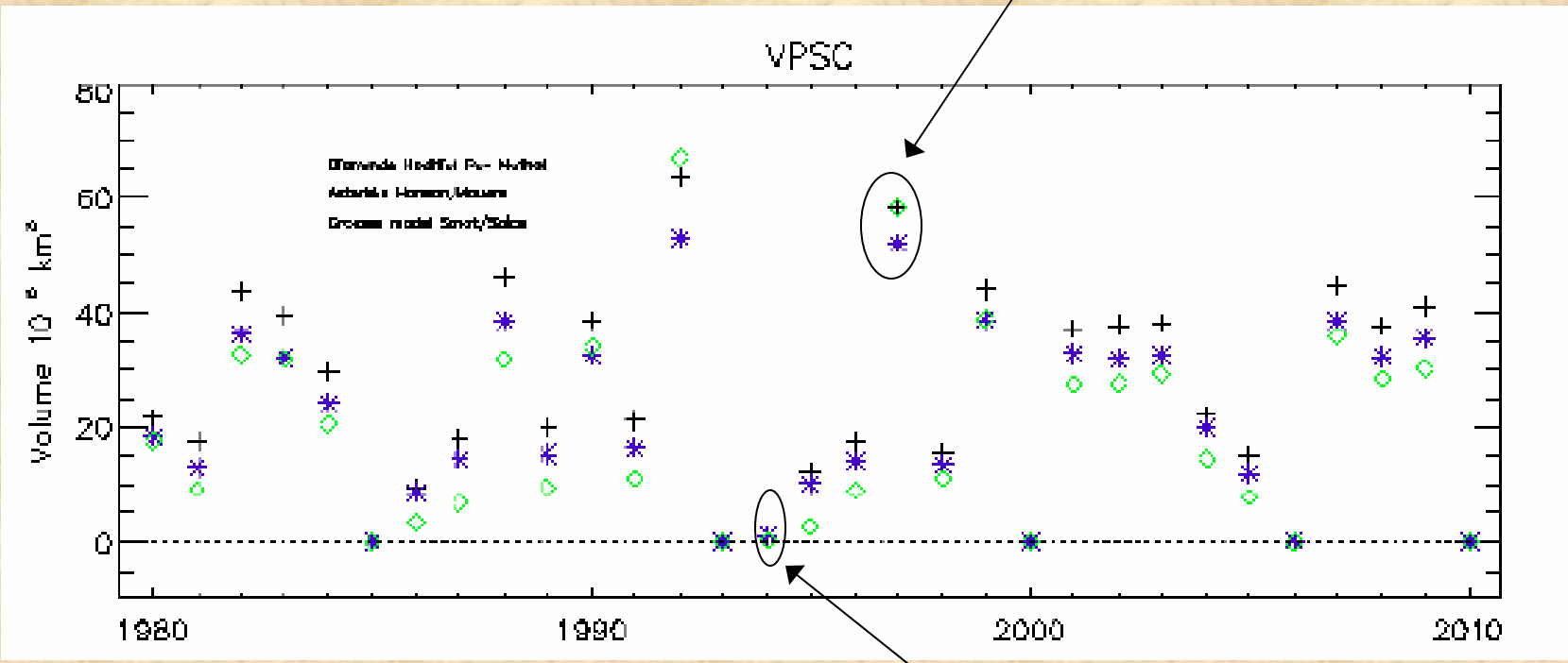


Figure 4. Polar chemical ozone loss. Variation of the overall chemical ozone loss in ten Arctic winters versus the winter-average of the volume of air sufficiently cold for PSC existence (VPSC). Measurements are shown by coloured squares. Black points are results from a chemical transport model. The slope of a fit through the points is a measure for the sensitivity of chemical ozone loss on changes in polar stratospheric temperatures and can be used to validate the representation of chemical ozone loss in CCM calculations (Rex *et al.*, 2003).

What can we learn from our models?

V_{psc} Calculated for Each Year of the 50-Year GEOS 4 GCM Simulation



Cold Hindcast Year

Warm Hindcast Year

Arctic Ozone Loss during Winter

- **Sinking air increases ozone in the vortex**
- **Polar air is processed by stratospheric clouds, increasing active chlorine by large factors**
- **Chemical ozone loss occurs as the sun rises and is greatly enhanced by PSC processing**
- **Calculated ozone loss is the net change in ozone plus the extra amount that was transported into the vortex**

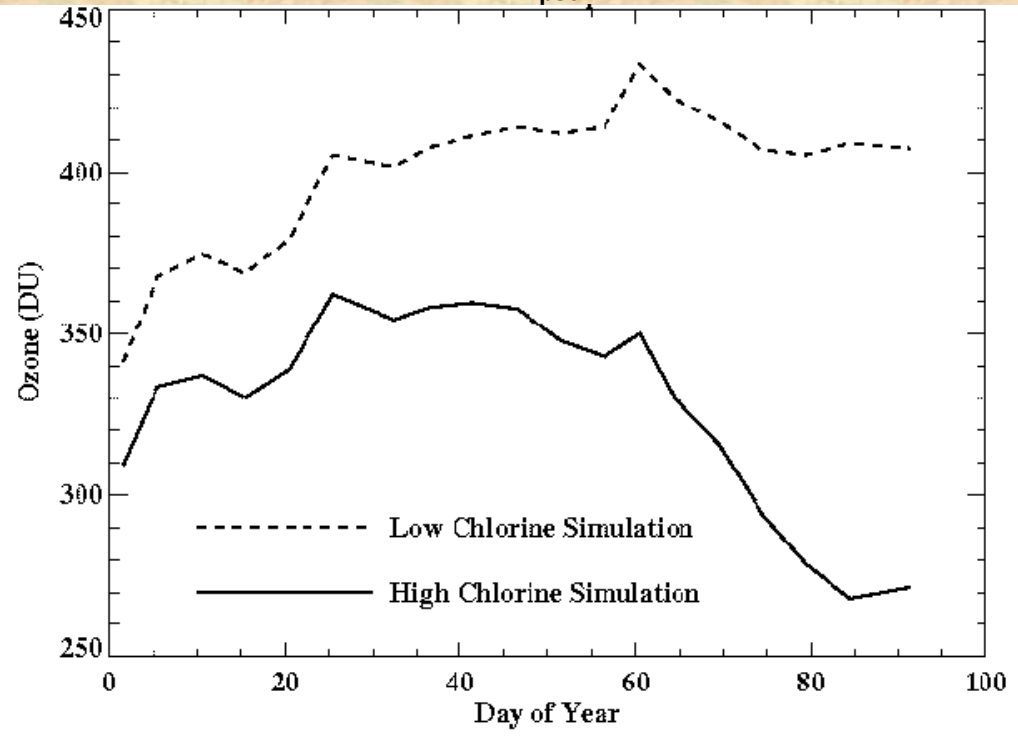
How Did We Calculate Ozone Loss?

- Calculated daily region of vortex (Nash criterion)
- Calculated area-weighted average of ozone in vortex from Jan1 through April 1 for both low chlorine and high chlorine simulations
- Differenced the high and low chlorine runs daily to get ozone loss as a function of time
- Used range of ozone loss from difference curve to determine winter total ozone loss

Calculation of Ozone Loss in Model

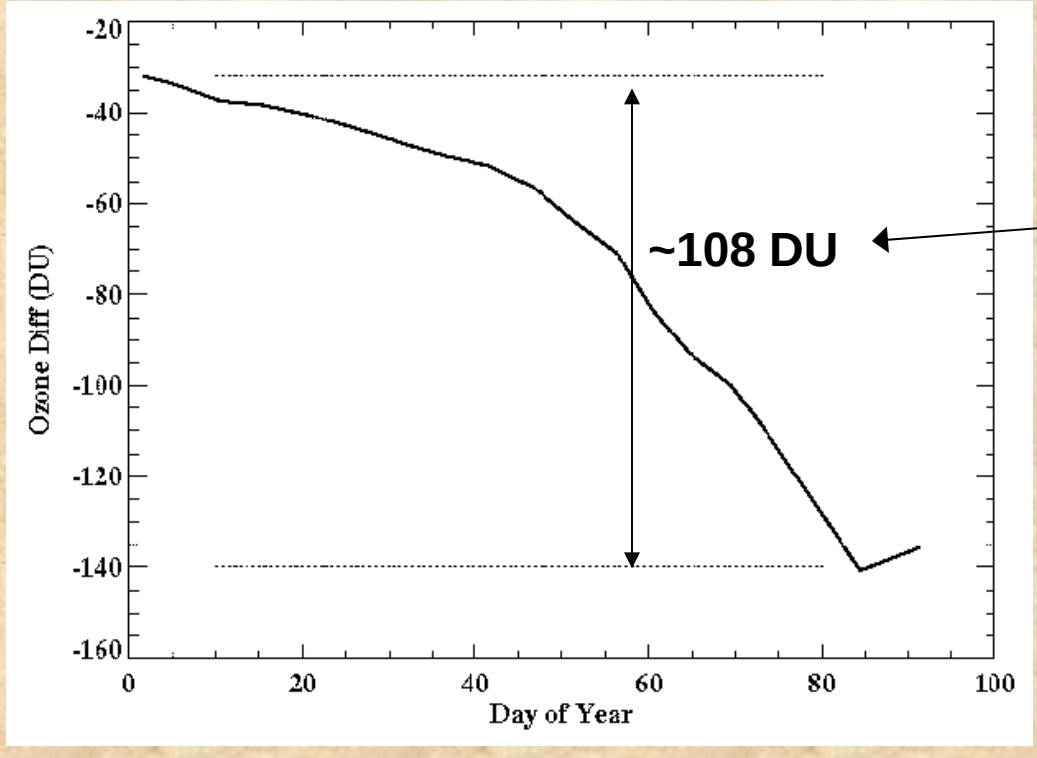
We have a great advantage in model because we have a second simulation with low chlorine and the same dynamics and temperatures as our high chlorine simulation

Model Year 1999: V_{psc} ~ 40 x 10^6 km^3



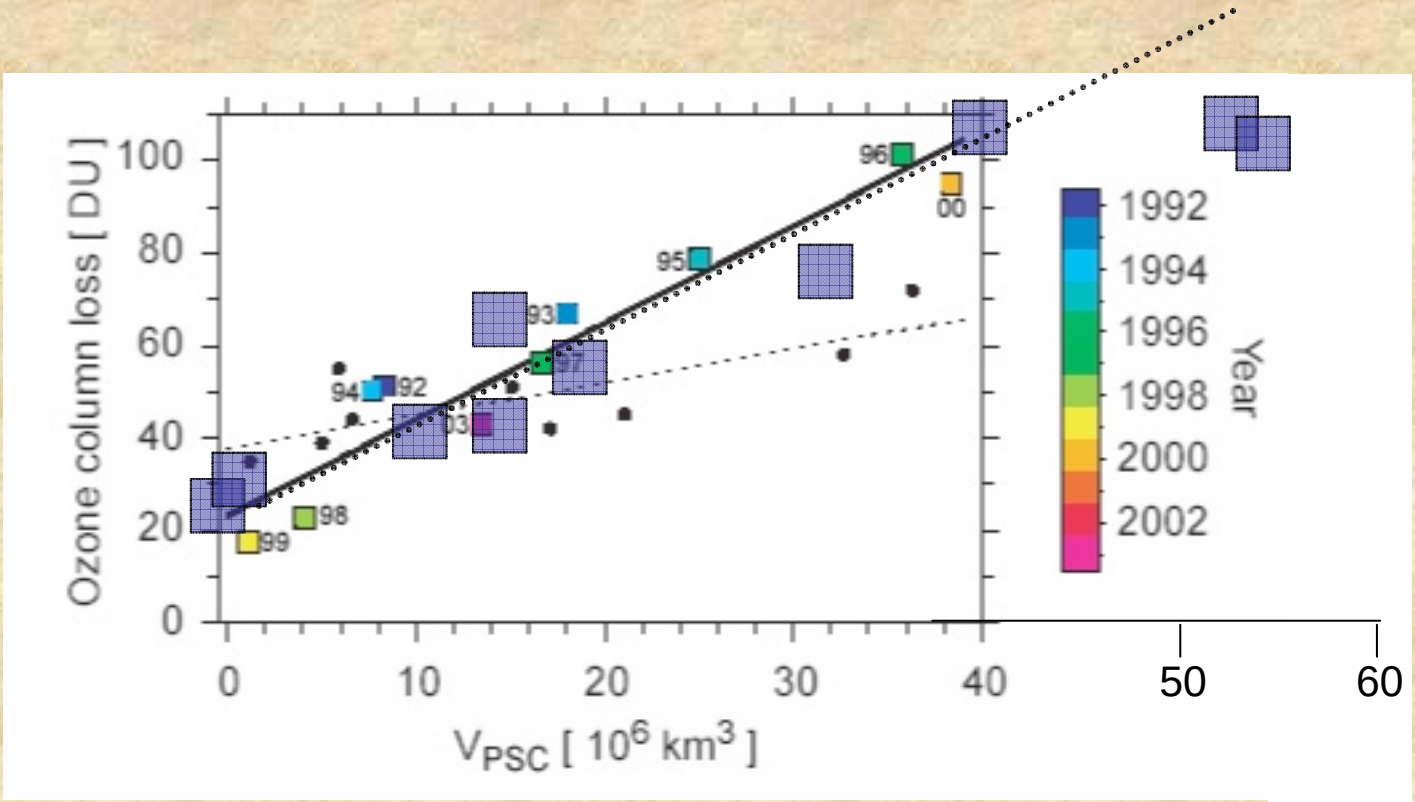
Ozone Difference between High and Low Chlorine Simulations Gives Ozone Loss vs Time

Model Year 1999: V_{psc} ~ 40 x 10^6 km^3



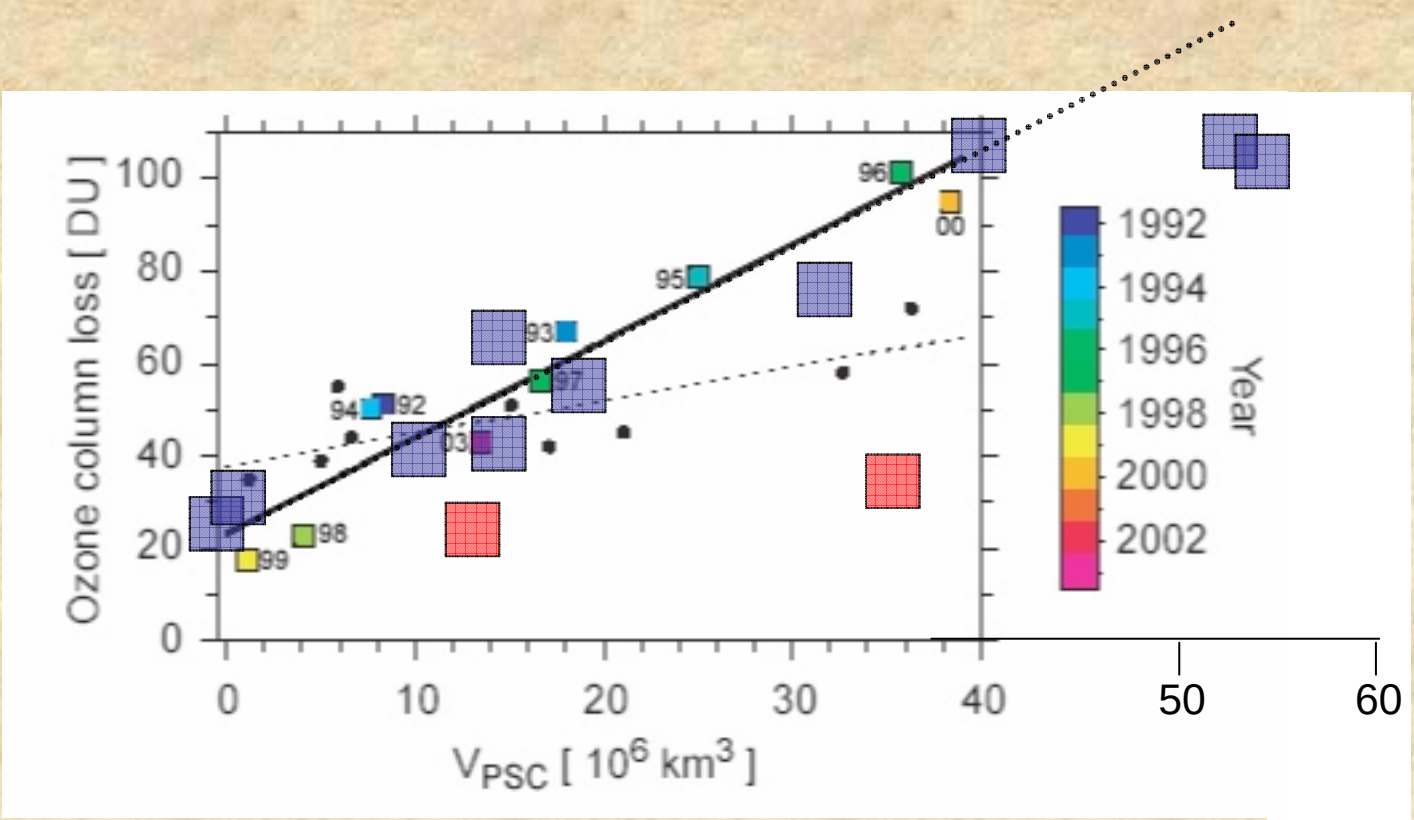
Range of loss curve gives total ozone lost in vortex during winter

Comparison of Model Ozone Loss vs V_{psc} to Empirical Determination from Data



Blue Squares - High Chlorine 1990-1999

Comparison of Model Ozone Loss vs V_{psc} to Empirical Determination from Data



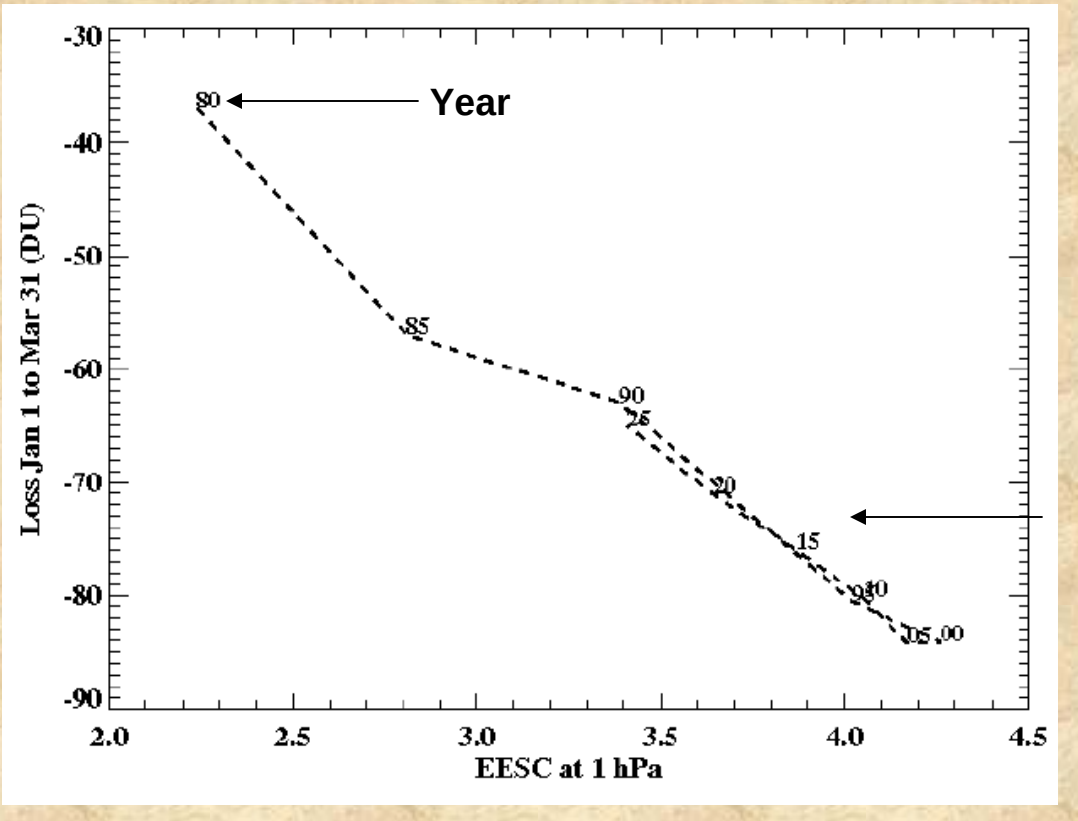
Blue Squares - High Chlorine 1990-1999

Red Squares - Lower Chlorine 1981-1982

GMI Hindcast Simulations

- Cold hindcast corresponds to V_{psc} of about 53 x 10^6 km^3
- Warm hindcast corresponds to V_{psc} of ~0
- Cold hindcast present opportunity to investigate Delta ozone vs V_{psc} for one value of V_{psc} as a function of chlorine amount

Delta Ozone at V_{psc} ~ 53 x 10^6 km^3 vs Equivalent Effective Stratospheric Chlorine



Note that as chlorine turns around, the loss retraces the same linear curve

Summary

- **Simulation reproduces shape (linear) of delta ozone vs Vpsc curve deduced from data**
- **Model shows apparent saturation of ozone loss at high Vpsc**
- **Hindcast shows approximately linear dependence of ozone loss as a function of equivalent chlorine amount (at high Vpsc)**
- **These results should be useful for deriving a surrogate for trend analysis that goes beyond the simple linear dependence of ozone on the equivalent chlorine**